Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC2
https://doi.org/10.5194/gmd-2020-384-RC2, 2021

Comment on gmd-2020-384

Anonymous Referee #2

Referee comment on "Vertical grid refinement for stratocumulus clouds in the radiation scheme of the global climate model ECHAM6.3-HAM2.3-P3" by Paolo Pelucchi et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2020-384-RC2, 2021

This paper describes the application of grid-refinement techniques to improve the cloud cover under inversions as seen by the radiation scheme in the ECHAM-HAM model. Ultimately, the attempts are unsuccessful in improving the mean model climate, which is somewhat sad as the paper is very well written. It leaves me quite uncertain what to suggest.

On one hand, I'm supportive of publishing a study like this, as it is useful to the community to know what has been done, and that (in this case) it doesn't really work. On the other, I'm unsure that the paper contains enough new material to be published. In particular:

- The method of grid refinement is not new, it is simply an application of an already published study (Grenier & Bretherton 2001).
- The idea of giving the radiation scheme the spatial area of cloud seen rather than the volume fraction is not new, but has been discussed by several previous studies (most recently Boutle & Morcrette 2010).
- Applying grid-refinement techniques to improve cloud cover has been more successfully implemented in other models, and so the application of this to a full GCM is not new. Further to this, the application in other models (e.g. Boutle & Morcrette 2010) has applied the technique to cloud variables throughout the model, rather than just to those seen by radiation. Therefore the previous studies on the topic seem to offer a more complete and consistent solution to the problem, and possibly unsurprisingly, have been more successful in demonstrating model improvements.

Therefore I'm struggling to see really what the new results being presented here are.

The best suggestion I can offer is to try the experiment applying SC-SUND to all cloud, not just that seen by the radiation. This would be consistent with how previous studies have applied similar techniques and demonstrated improvement. It would seem that you've done all the hard work in coding up the new scheme, and therefore linking it in to the main cloud water/fraction variables is a trivial extra step. This would (hopefully) not only allow you to show a model improvement that ECHAM-HAM developers/users would be interested in, but also allow discussion of why only applying the scheme to the radiation does not work. I feel discussion of this point is somewhat lacking in the current paper. The expectation is clearly that this is the most important term in the cloud budget, and therefore should be sufficient - so why isn't it? It looks from Fig 6 that the increase in cloud from SC-SUND (e) is almost comparable to the bias in main model cloud (b). So is having improved radiative fluxes in these regions (I assume they are improved - this is something else that could be shown and discussed in the paper) not feeding back onto the inversion structure in a way that allows the cloud to form properly there? Or is the model vertical grid so coarse and inadequate that there is no hope of ever forming cloud correctly there? Both of these would clearly motivate diagnosing the full model cloud quantities using SC-SUND, as this will compensate for the poor vertical resolution, but also allow further improvements to the radiative fluxes and inversion structure, feeding back onto the cloud properties.

My other suggestion would be to link the discussion to recent literature a bit more. Sundqvist-type cloud schemes that use a critical relative humidity are somewhat arcane and will always struggle around inversions due to the mixing of boundary-layer and free tropospheric air masses in a way that cannot be represented by a simple monomodal PDF and critical relative humidity. A (very) recent set of papers (van Weverberg et al. 2021a,b) has discussed this in detail, demonstrating that really the cloud properties here need to be considered as bimodal, and representing them otherwise probably places fundamental limits on how good the cloud can ever be near an inversion.

Refs:

van Weverberg, K., Morcrette, C. J., Boutle, I., Furtado, K. and Field, P. R. (2021). A Bimodal Diagnostic Cloud Fraction Parameterization. Part I: Motivating Analysis and Scheme Description. Mon. Weather Rev., doi:10.1175/MWR-D-20-0224.1

van Weverberg, K., Morcrette, C. J. and Boutle, I. (2021). A Bimodal Diagnostic Cloud Fraction Parameterization. Part II: Evaluation and Resolution Sensitivity. Mon. Weather Rev., doi:10.1175/MWR-D-20-0230.1